Optimization of the Distribution Route of Campus Emergency Aid Supplies using an Improved Bee Colony Algorithm

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***Abstract* — This paper deals with the optimization of the distribution route of campus emergency aid supplies using an improved bee colony algorithm. The scheduling problems of the logistics distribution business is analyzed in terms of transportation resource utilization and distribution services cost. Specific examples are used to verify the effectiveness and stability of the algorithm. The paper presents a novel attempt to broaden the scope of application of artificial bee colony algorithms and proposed a new feasible means to solve similar problems.**

Keywords - artificial bee colony algorithm; optimization distribution route; campus emergency aid.

I. INTRODUCTION

In recent years, with the continue advance of urbanization and the rapid development of the Internet environment e-commerce, the logistics industry showing a rapid development momentum and becoming "the third profit source." But it is also has a problem that the high logistics cost. Logistics delivery is the most important part of logistics system. At the cost of logistics activities, in addition to procurement costs, distribution costs are the highest proportion, therefore, reasonable arrangements for distribution programs, reduce logistics costs related to the company's overall operating efficiency.

The main content of logistics delivery is the Vehicle Routing Problems (VRP), means to take the determine goods to the determine location in a specified time and a certain way by a minimal cost. VRP was first proposed by Dantzig and Ramser [1] in 1959, which attracted great attention sonly, and it is still a research focus in the field of operations research and combinatorial optimization. In the premise to meet the diverse user demand, how to use available resources effectively to optimize vehicle routing, reduce distribution costs and improve economic efficiency of enterprises is the goal of the logistics industry development.

Artificial Bee colony algorithm was used in the mul-timodal function optimization problem originally. Artificial bee colony algorithm has the features of simpleness, less control parameters, high accuracy and robustness strong search, and it has great advantages in solving multidimensional combination optimization problems.

This paper use the ABC algorithm in VRP problem, the experimental results show that the ABC algorithm is a viable means to solve such problems.

II. APPLICATION OF ARTIFICIAL BEE COLONY ALGORITHM IN TRANSPORTATION SCHEDULING

Artificial Bee colony algorithm is proposed by Karaboga [2] in 2005, which is an intelligent optimization algorithm by analog honey bee behavior. The principle of bee populations is shown in figure 1.

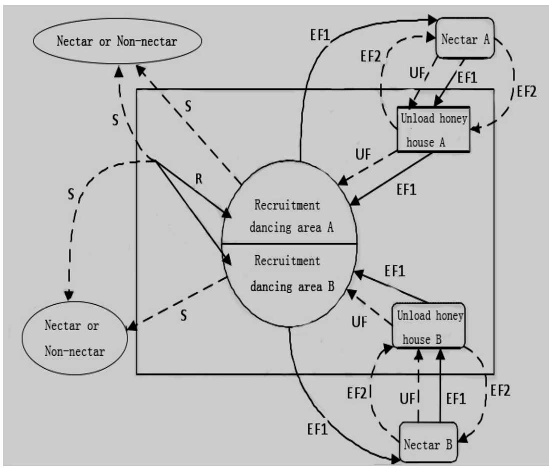

Figure 1 The principle of bee populations

Artificial bee colony algorithm is a new type of swarm intelligence heuristic optimization algorithm, which was proposed to solve combination optimization problems originally. Artificial bee colony algorithm has characteristics of small parameter control, simple realization and good robustness. Artificial Bee colony algorithm was used in the multimodal function optimization problem originally. Compared with other classical optimization methods, Artificial bee colony algorithm almost has no requirements in terms of objective function and constraints, and it has good adaptability for solving a multi-optimization objective and multi-constraint combinatorial optimization problems. So this artificial use the artificial bee colony algorithm to solve problem, and comparison with genetic algorithms, to verification the artificial bee colony algorithm is better than genetic algorithm.

When using artificial bee colony algorithm to solve problem, it need to be mapped between the practical issues and algorithm models. The specific mapping is shown in Table 1. By mapping the related data in scheduling problems and the parameters in algorithms model, we can use the artificial bee colony algorithm to solve scheduling problem effectively [3].

TABLE I MAPPING BETWEEN THE SCHEDULING PROBLEMS AND THE ARTIFICIAL BEE COLONY ALGORITHM MODEL

Artificial bee colony algorithm model	**Scheduling problems model**
Food source	Distribution program
Possible values of feasible solution for each dimension	Coding of each customer point
he objective function	Delivery Service shipping costs

III. THE BASIC PRINCIPLES OF ARTIFICIAL BEE COLONY ALGORITHM

In artificial bee colony algorithm, a food source represents a feasible solution in the optimization problem, and the richness of the food source represents the quality of the solution (fitness). Employment Bee and food sources are correspondence, so the number of employment bee represents the number of solution. Compared with other classical optimization methods, Artificial bee colony algorithm almost has no requirements in terms of objective function and constraints, and it has good adaptability for solving a multi-optimization objective and multi-constraint combinatorial optimization problems.

The solving ideas of artificial bee colony algorithm are as follows, firstly Randomly generate SN solutions and constituting a initial population P，the population size is SN, each solutions $\mathrm{X}_i (i = 1,2,...,SN)$ is an N-dimensional vector. After population initialization, the employment bee began a local search in neighborhood of solutions, when the employment bee find a better fitness solution, discard the original solutions and record the new solution. According to the solutions information obtained from employment bee, Observation bee choose a best solutions it thinks and local search the vicinity of the solutions. Similarly, record new solutions when find a better [4].

When one solution has not been updated in a long period of time, it means that in the neighborhood of the solution has not a better solution, then the employment bee associated with the solution will drops it, becomes a scouts bee and randomly generate a new solution again. Then one iterative process is completed. In the iterative process, it will record the highest fitness solution in all the feasible solution. After several iterations, the highest fitness solution in the recording will be the global optimal solution. In the process, three bees play different roles: the role of employment bee is to maintain issues an excellent solution, the role of observation bee is to improve the convergence rate; the role of scout bee is to improve the global optimization capability and to avoid falling into local optima excellent.

In the population initialization phase, all the solutions generated by equation 1:

$$\mathrm{X}_{\mathrm{m,i}} = I_i + rand(0,1) * (u_i - I_i) \tag{1}$$

In equation 1, $\mathrm{X}_{\mathrm{m,i}}$ is the i-th dimension of the m-th solution. u_{i} and I_{i} is the Lower and upper value limits of parameter $\mathrm{X}_{\mathrm{m,i}}$.

The employment bee will search a new solution V_{m} in the neighbor domain of the recorded solution X_{m}, and calculate the fitness function value of the new neighbor solution. Search of the neighbor solution through equation 2.

$$\mathrm{V}_{\mathrm{m,i}} = X_{m,i} + \phi_{m,i}(X_{m,i} - X_{k,i}) \tag{2}$$

In equation 2, X_{k} is a known solution randomly selected and i is the dimension of solution, $\phi_{\mathrm{m,i}}$ is a random number in the range of [-1, 1].

After the new neighbor solution is found, we need to calculate its fitness function value by use equation 3. Compare fitness of the known solution and new solution; select a solution with high fitness degree to retain according to the greedy strategy.

$$fit(X_m) = \begin{cases} \dfrac{1}{1+f(X_m)}, f(X_m \geq 0) \\ 1+abs(f(X_m)), f(X_m < 0) \end{cases} \tag{3}$$

In equation 3, $fit(X_m)$ is the fitness function of solution X_m, it means the quality level of solution. $f(X_m)$ is the objective function value of X_m.

Employment bee share the information they get to the solution, after observation bee get all current solutions information from the employment bee, it will choose a solution thought the corresponding probability of the fitness value solution, and do one-step search in the neighborhood of solution. the probability of choose solution X_m is p_m ,calculated as equation 4:

$$p_m = \frac{fit(X_m)}{\sum_{m=1}^{SN} fit(X_m)} \tag{4}$$

SN is the population size.

After observation bee chooses a solution, it will find a new solution in the neighborhood of solution, the way to find

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new solution is same to the employment bee, calculated as equation 2 [5].

When a solution has not been updated in a number of iterations, it shows that the algorithm goes into a local optimum, this solution will be discarded and regenerate a random solution by the scout bee to instead. Therefore, it needs to set up a local maximum cycle number to improve the global optimization ability.

According to the above artificial bee colony algorithm idea, we can get the main flow of the algorithm, the algorithm flow chart shown in figure 2 [6].

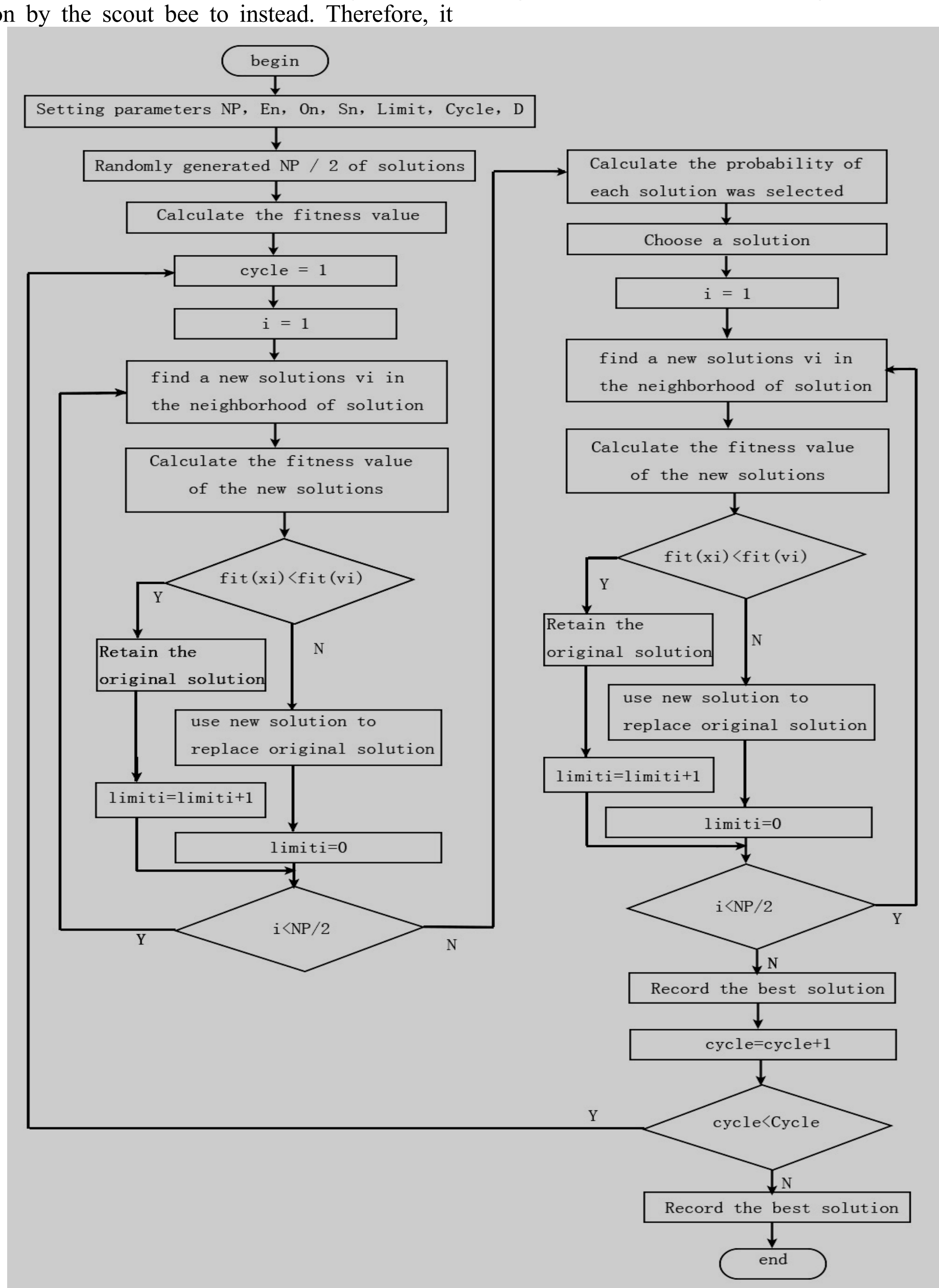

Figure 2. Artificial bee colony algorithm flowchart

Step 1: Identify the main parameters of the artificial bee colony algorithm: population size NP, employment bee quantity En, observation bee quantity On, scouts bee quantity Sn, the local maximum search number Limit, the iteration number Cycle and the solution dimension D.

Step 2: Randomly generated NP/2 solutions, initialization population and calculate the fitness value of each solution.

Step 3: Define the Iteration number variable cycle = 1 and goes the iterative process.

Step 4: Through all the solutions, perform Step5-Step8 for each solution.

Step 5: Looking for a new solution in the neighborhood of the solution.

Step 6: Computing the fitness function value of the new solution.

Step 7: Retain the optimum solution of the original solutions and new solutions according to the greed principle.

Step 8: If the solution is not updated, the local search frequency variable limit = limit + 1. If the solution is updated, the local search frequency variable limit = 0.

Step 9: Calculate the probability value of each solution that selected by the observation bee.

Step 10: Each observation bee selects a solution according to the select probability value in step 9, does a local search to find a new solution in the vicinity of the solution and evaluates the fitness of new solution. Retain the optimum solution of the original solution and new solution according to the greed principle. If the solution is not updated, the local search frequency variable limit = limit + 1. If the solution is updated, the local search frequency variable limit = 0.

Step 11: Through all the solutions, analyzing whether the corresponding limit achieve the local maximum search number. If the limit <Limit, discard the solution and generate a new solution to instead.

Step 12: Recording the optimal solution.

Step 13: Incremental iteration number, cycle = cycle +1.

Step 14: If it has reached the global maximum cycle number Cycle, go to Step 4. Otherwise, the recording solution in Step 12 is the global optimal solution.

IV. THE OPTIMIZATION RESEARCH OF THE PARK LOGISTICS DISTRIBUTION ROUTE BASED ON THE IMPROVED BEE COLONY ALGORITHM

A. Experimental Content

In order to validate algorithm performance, this paper uses the following problem to simulate experimentation. A logistics center delivery to 8 customers, distance between the distribution center and the customers as shown in table 2, service time range and service time customer requirement as shown in table 3. Vehicle maximum load is 8t, vehicle speed is 50km / h. It requires arrangement the vehicle travel path reasonable, so that the total vehicle traveling distance shortest.

TABLE II THE DISTANCE BETWEEN THE CUSTOMER AND THE DISTRIBUTION CENTER

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	0	42	58	71	187	105	150	90
2	50	0	66	45	80	110	75	100
3	75	40	0	100	100	75	75	75
4	90	100	100	0	75	80	90	150
5	200	50	100	40	0	70	90	80
6	100	75	70	55	80	0	60	120
7	180	160	110	80	140	85	0	100
8	80	100	85	150	100	75	100	0

TABLE 3 THE CUSTOMER DEMAND AND TIME WINDOW

The delivery point	1	2	3	4	5	6	7	8
The distribution volume	2.5	2	4	3	1	4	3	3
The service time	2	3	2	4	3	3.2	4	1.7
The time window	[1-4]	[4-6]	[2-3]	[5-7]	[4-6]	[3-7]	[4-9]	[2-4]

B. Experimental Principle

1) Initial population

According to the characteristics of the problem, this paper uses the following encoding and decoding schemes: randomly generated a 1-L natural number arrangement, then use a path decode operator based on the greed construction method to decode the path. For example, solute 2 7 5 8 6 1 3 4, firstly the decoding operator takes 2 included into the first line, determine whether satisfy the constraints, if satisfy, put 7 into the first line, determine whether satisfy the constraints, if satisfy, put the next number into the first line, if not, then make a second line which begin with 7. Calculate continuously until decoded. If the line number is greater than the total number of vehicles, then it is a feasible solution, regenerate a new solution instead. The arrangement represents a guidance bee travel route, the coding scheme employed, implied the constraint that each city travel only once, which represents a feasible solution. Set the population size is N, thought randomly generating N individuals to form the initial population. Because of the constraints of the problems, the solution randomly generated mostly infeasible solutions. This approach not only makes sure all the solutions are feasible solutions, and natural number encoding more intuitive [7].

2) Fitness of the evaluation method

According to the objective function of the problem, select the fitness is the reciprocal of distance. The path route longer, the fitness lower, the food source income smaller, and the probability of being selected lower.

3) Chosen of the neighborhood search strategy

In the original algorithm the neighborhood search is based on the equation 2. As the equation results are decimal, it does not fit on the VRPTW problem, so this paper uses the following methods to achieve neighborhood search: randomly generated an interval [k, j] in a solution, then reverse order numbers within the interval [8].

4) Scouts bee choose a new food source

Each observation bee selects a solution according to the select probability value in step 9, does a local search to find a new solution in the vicinity of the solution and evaluates the fitness of new solution. Retain the optimum solution of the original solution and new solution according to the greed principle. If the solution is not updated, the local search frequency variable limit = limit + 1. If the solution is updated, the local search frequency variable limit = 0. Through all the solutions, analyzing whether the corresponding limit achieve the local maximum search number. If the limit <Limit, discard the solution and generate a new solution to instead.

5). The termination criterion

This paper take the largest circulation algebra termination criterion, as shown in Figure 3.

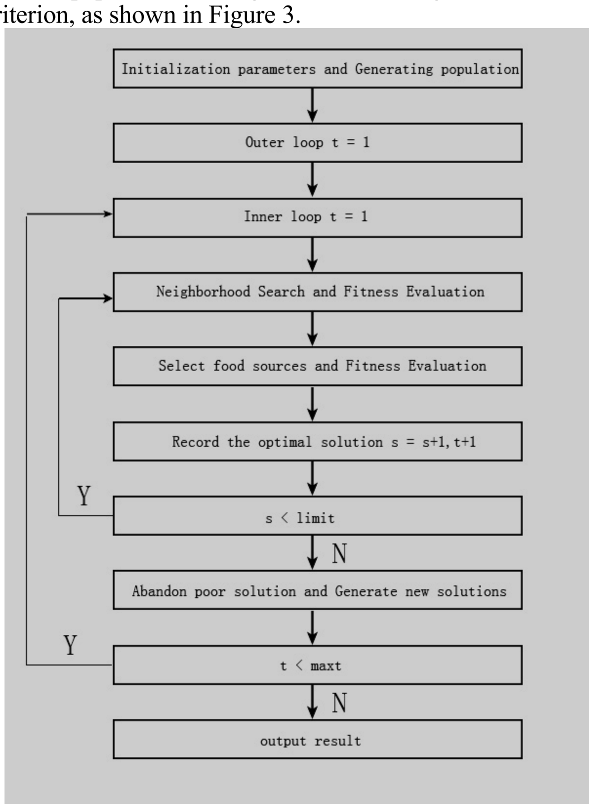

Figure 3 The Artificial bee colony algorithm flowchart in this paper

6).Parameters select

The Artificial Bee colony algorithm parameter is set to: N = 10, max = 100, limit = 10.

7) Experimental results

Random solved 10 times, get the known optimal solution of the problem is 910km. One path is: 0 → 3 → 1 → 2 → 0; 0 → 6 → 4 → 0; 0 → 8 → 5 → 7 → 0. It shows that use Artificial Bee colony algorithm can quickly and efficiently obtain the optimal solution or near optimal solution.

V. CONCLUSION

This paper uses the Artificial Bee Colony algorithm for the VRP problem, the experimental results show that the ABC algorithm is a viable means to solve such problems. On one hand, as a new optimization algorithm, the research about the ABC algorithm has just started. This paper made a valid attempt to broaden the scope of application of artificial bee colony algorithm. On the other hand, it also proposed a new feasible means to solve similar problems.

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REFERENCES

[1] Dantzig G,Ramser J. “The truck dispatching problem”.Management Science vol.6,pp.80-91, 1959.

[2] Karaboga D. “An idea based on honey bee swarm for numerical optimization”.TechnicalReport-TR06.ErciyesUniversity, 2005.

[3] Yingwei Zhang, Dianhui Chu, Fanchao Meng. “Study on multi-type vehicle routing problems with integrated pickups and deliveries based on artificial bee colony algorithm”. New Information Communication Science and Technology, 2014.

[4] Sundar S, Singh A, Rossi A. “An artificial bee colony algorithm for the 0-1 multidimensional knapsack problem”. Communications in Computer and Information Science, vol.94,No.1,pp.141-151, 2010.

[5] Sonmez M. “Artificial bee colony algorithm for optimization of truss structures”. Applied Soft Computing, vol.11,No.2,pp.2406-2418, 2011.

[6] Ashita S. “Artificial bee colony (ABC) algorithm for vehicle routing optimization problem”. International Journal of Soft Computingand Engineering, vol.2,No.2 , 2012.

[7] Karaboga D, Akay B. “A modified artificial bee colony (ABC) algorithm forconstrained optimization problems”. Applied Soft Computing, vol.11,No.3,pp.3021-3031, 2011.

[8] Srinivas P, Chao Z. “Stochastic quasi-gradient algorithm for the off-line stochasticdynamic traffic assignment problem”. Transprotation Research Part B:Methodological, vol.40,pp.179-20, 2006.